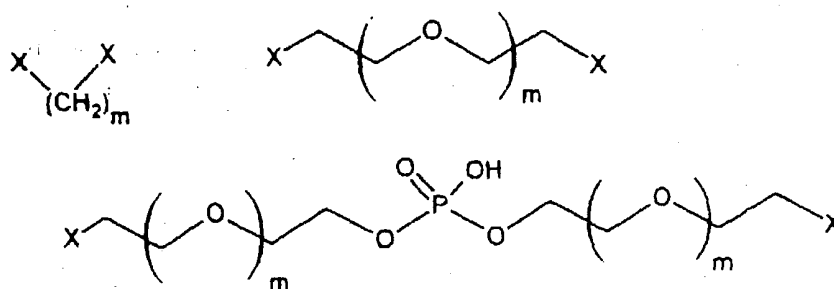


CLAIMS

1. Method for the attachment and self-organization of biological macromolecules, characterized in that it comprises the incubation, without stirring, for at least 15 minutes, of a biological macromolecule in solution with nanotubes of carbon closed at their ends, under suitable temperature and pH conditions.
2. Method according to Claim 1, characterized in that the said biological macromolecules are in particular soluble, membrane or transmembrane proteins, enzymes, antibodies, antibody fragments or nucleic acids.
3. Method according to Claim 1 or Claim 2, characterized in that the said nanotubes of carbon are functionalized by physical adsorption, at their surface, of a chemical reagent of general formula **H-E-L**,
in which:
 - **H** represents a hydrophilic group selected from the positively or negatively charged groups; ligands or analogues of biological macromolecules; organometallic complexes interacting with amino acids or nucleic acids and whose ligands are optionally functionalized with alkyl groups for bonding to **E**;
 - **E** represents a spacer arm, selected from C₁-C₁₀ carbon chains, optionally substituted with alkyl groups, having unsaturations or otherwise or polyoxyethylene units which may have or otherwise in the middle of the chain phosphate groups, such as:

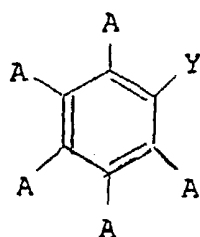


in which:

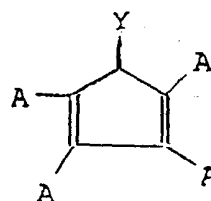
m represents an integer from 1 to 10,

5 X represents O, NHCO, OCO, COO, CONH, S, CH₂ or NH and constitutes, at the ends of the said carbon chains, organic functions for adhesion of the ester, amide, ether or thioether type;

10 - L represents a lipid unit with one or more chains of variable length, in the form of C₁₂-C₂₀ having unsaturations or otherwise; an aromatic group of formula Ar₁ or of formula Ar₂:



Ar₁



Ar₂

15

in which:

A represents a hydrogen atom, one of the following groups: alkyl, CF₃, NO₂, NH₂, OH, O-alkyl, S-alkyl, COOH, halogen, an aromatic ring or an aromatic
20 heterocycle in the form of C₄-C₆, optionally polysubstituted with electron-donating groups of the alkyl type or electron-attracting groups of the CF₃ or halide type; and

Y represents a bond with E.

25 4. Method according to any one of Claims 1 to 3, characterized in that the said solution consists of a

solvent for solubilizing the said biological macromolecules, which is aqueous or aqueous-alcoholic and which optionally contains at least one detergent.

5. Method according to any one of Claims 1 to 4, characterized in that the incubation conditions are preferably the following: incubation at room temperature, for 15 minutes to 48 hours, at a pH of between 5.5 and 8.5.

6. Bionanomaterials, characterized in that they consist of nanotubes of carbon, on which biological macromolecules are self-organized in a crystalline form.

7. Bionanomaterials according to Claim 6, characterized in that they are obtained with the aid of a method according to any one of Claims 1 to 5.

8. Use of the bionanomaterials according to either of Claims 6 and 7, for the structural study of the biological macromolecules which are associated with them.

9. Use of the bionanomaterials according to either of Claims 6 and 7, as biological reagent.

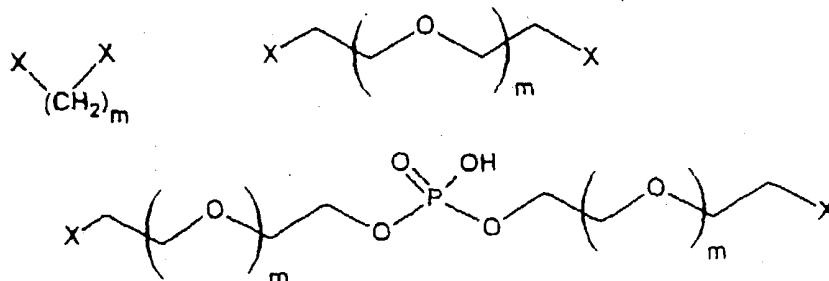
10. Use of the bionanomaterials according to either of Claims 6 and 7, as biosensors or bioconductors.

11. Chemical reagent capable of being physically adsorbed on nanotubes of carbon, characterized in that it has the general formula **H-E-L**, in which:

- **H** represents a hydrophilic group selected from the positively or negatively charged groups; ligands or analogues of biological macromolecules; organometallic complexes interacting with amino acids or nucleic acids and whose ligands are optionally functionalized with alkyl groups for bonding to **E**;

- **E** represents a spacer arm, selected from C_1 - C_{10} carbon chains, optionally substituted with alkyl groups, having unsaturations or otherwise or

polyoxyethylene units which may have or otherwise in the middle of the chain phosphate groups, such as:



5

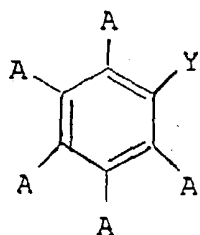
in which:

m represents an integer from 1 to 10,

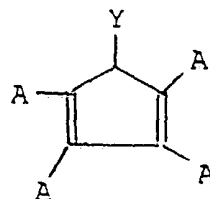
X represents O, NHCO, OCO, COO, CONH, S, CH₂ or NH and constitutes, at the ends of the said carbon chains, organic functions for adhesion of the ester, amide, ether or thioether type;

10

- L represents an aromatic group of formula Ar₁ or of formula Ar₂:



Ar₁



Ar₂

15

in which:

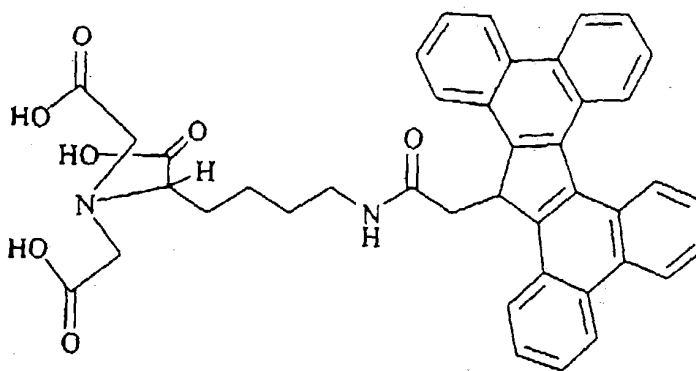
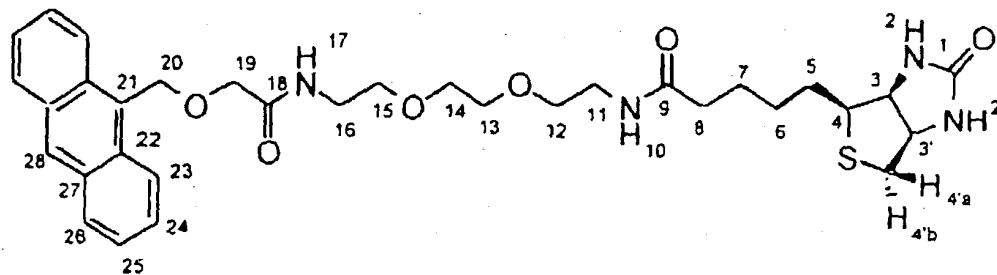
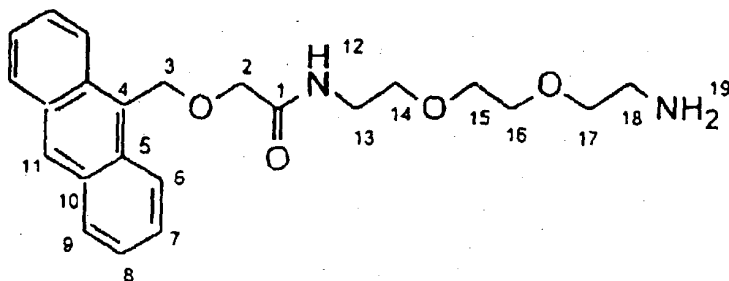
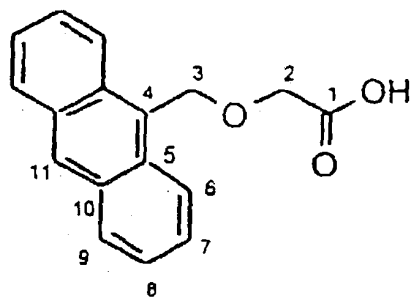
A represents a hydrogen atom, one of the following groups: alkyl, CF₃, NO₂, NH₂, OH, O-alkyl, S-alkyl, COOH, halogen, an aromatic ring or an aromatic heterocycle in the form of C₄-C₆, the said rings being optionally polysubstituted with electron-donating groups of the alkyl type or electron-attracting groups of the CF₃ or halide type; and

20

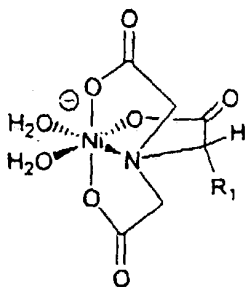
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Y represents a bond with E.

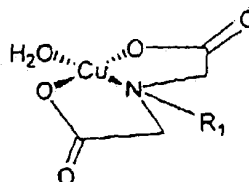
12. Chemical reagent according to Claim 11, characterized in that it has one of the following structures:



13. Chemical reagent according to Claim 11, characterized in that H is selected from the following organometallic complexes:



Ni-NTA complex



Cu-IDA complex

with R_1 = organic group for bonding to E.